U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 209.

CONTROLLING THE BOLL WEEVIL IN COTTON SEED AND AT GINNERIES.

BY

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WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1904.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., September 16, 1904.

SIR: I herewith transmit a manuscript by Mr. W. D. Hunter, special agent of this Bureau in charge of the experimental work with the Mexican cotton boll weevil in Texas. The subject investigated in this paper is one of the very greatest importance to the cotton interests in the South, namely, the control of the boll weevil in cotton seed and at ginneries; and on account of the fact that the ginning season is now at its height and that the farmers in Texas and Louisiana will soon be obtaining seed for planting purposes, I recommend the immediate publication of this paper as a Farmers' Bulletin.

Respectfully,

L. O. HOWARD,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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CONTROLLING THE BOLL WEEVIL IN COTTON SEED AND AT GINNERIES.

COTTON SEED AND GINNERIES AS FACTORS IN THE SPREAD OF THE BOLL WEEVIL.

The extent to which cotton seed and ginneries are factors in the dissemination of the boll weevil has not been realized generally. During the present season the Bureau of Entomology has paid particular attention to this matter and has demonstrated that ginneries are the most important single factors in disseminating the pest. At least in regions where the cotton fields are somewhat isolated, spreading of the insect by flight, aided by the wind, seems to be of little importance compared with this artificial agency. The cooperation of this Department with the Louisiana crop pest commission, which is engaged in an attempt to prevent the further entrance of the weevil into that State, has given many opportunities for determining the exact means whereby weevils reach new regions. At the present time this work has led to the conclusion that if it were possible to control the pest at gins, it might be possible to greatly retard its present rate of spreading, but that without any such means of control there is great doubt about the feasibility of an attempt to check its spread, unless, indeed, measures are taken to prohibit in uninfested localities the ginning of cotton from infested regions. Early in the season of 1903 five trained men connected with this Bureau were stationed in the western parishes of Louisiana. The infested fields have been determined very carefully, and a special study has been made of the means by which they became infested. It was soon found that Texas cotton growers along the Sabine River were accustomed to ginning their cotton in Louisiana. Various localities in the eastern tier of counties in Texas have been infested for nearly two years. One farmer by bringing seed cotton from Texas to Louisiana gins would cause those gins to become infested. From these infested gins the spread of the weevil has been traced carefully. In some cases customers of an infested gin changed to an uninfested one during the season and thus carried weevils with them. Instances have also been recorded where farmers collected seed from uninfested cotton on wagon sheets at a gin where

infested cotton had also been ginned. In these cases no infestation has been attributable to the seed so collected. In one case, however, a farmer was known to have collected the seed on a sheet in the way described, and during the present season it was found that the only field on his farm where the weevil is found was that to which he had hauled bulk seed for fertilizer from the same gin at which he had so carefully guarded his cotton seed. One farmer in Calcasieu Parish ginned his cotton partly at an infested and partly at an uninfested gin. It has been found that the weevils upon his plantation occur only in the fields grown from seed brought from the infested gin.

In a sparsely settled country, like the western portion of Calcasieu Parish, where the cotton fields are small and the gins consequently located at considerable distances from one another, the weevils have been carried astonishing distances. Prof. H. A. Morgan, secretary of the Louisiana crop pest commission, has furnished the writer with many interesting examples of this. In one case it has been ascertained that a farmer in the neighborhood of Merryville transported the pest for 16 miles, thus establishing an isolated infestation. That the occurrence of the pest in this locality was not due to its being blown by the wind is demonstrated by the fact that no other cotton fields in the neighborhood are infested, the neighbors having ginned their cotton outside of the infested territory.

In Shelby County, Tex., a dozen farmers procured seed of a desirable variety of cotton, which, though grown in the immediate uninfested locality, had been ginned farther west, where the weevils were very numerous. On the dozen farms upon which this cotton is growing the present season weevils have invariably been found, although surrounding fields planted from seed that was ginned in the immediate neighborhood have been found to be uninfested.

CONTROL OF BOLL WEEVIL IN SEED BY FUMIGATION.

As soon as the facility with which the boll weevil is disseminated in cotton seed was understood, the Bureau of Entomology devoted considerable attention to the possibility of destroying the pest by fumigation.[a] Only two gases seem to be at all suitable for this purpose. These are carbon bisulphid and hydrocyanic acid gas, the consensus of opinion among entomologists favoring the former as a fumigant for stored grains. Both of these gases have their drawbacks. As against the danger from the inflammable and explosive properties of carbon bisulphid, there is the danger to human life by the careless use of hydrocyanic acid gas. Experiments by Hicks and Dabney, of the

[a] Dr. A. W. Morrill and Mr. W. W. Yothers assisted in the fumigation experiments. In these experiments, as well as in all the work leading to the present bulletin, the writer was very materially aided by his principal assistant, Dr. W. E. Hinds.

Division of Botany of the Department of Agriculture, with carbon bisulphid, and Townsend, formerly of the Maryland Experiment Station, with hydrocyanic acid gas, show that the germinating power of the seed would not be lessened by treatment with either of these materials. As a matter of fact, numerous experiments that have been performed in connection with the present work have fully substantiated the results obtained by other investigators.

Carbon bisulphid seems to be much cheaper for use in the fumigation of cotton seed than is hydrocyanic acid gas. The former at the rate of 1½ pounds per 1,000 cubic feet would cost about 15 cents for 1,000 cubic feet, while for fumigation for the same space with hydrocyanic acid gas at least 10 ounces of potassium cyanide would be required. This would cost about 25 cents, to which must be added about 2½ cents for the sulphuric acid, bringing the cost up to nearly twice as much as in the case of the former fumigant. Mr. C. L. Marlatt and others have remarked about the greater resistance of weevils to hydrocyanic acid gas than to carbon bisulphid. These observations have been fully verified in the case of the boll weevil by investigators who have conducted the work.

FUMIGATION EXPERIMENTS.

In order to test the relative adaptability of these gases, and to determine the conditions under which they may be used effectively, a number of experiments were performed.

Experiment with hydrocyanic acid gas.

Rate per cubic foot.	Distance of weevils from surface.	Time.	Results.	Remarks.
Grams.	*Inches.*	*Hours.*		
0.25	8 to 10	3	Alive	
.25	12	3	do	
.30	3 to 4	5	do	A fly killed.
.30	6 to 8	5	do	A fly alive.
.30	12	5	do	Do.
.50	0	5	Dead	
.50	6 to 8	5	Alive	
.50	8 to 10	5	do	

In this experiment weevils in tin boxes, perforated in such a manner as to allow the free access of the gas, were buried at varying depths in sacks containing 100 pounds of cotton seed. The sacks were inclosed in a specially prepared tight box. The cyanide was lowered into the sulphuric acid through a small orifice in the lid.

As will be noted, the hydrocyanic acid gas, in a strength twice as great as is successfully used for the fumigation of grain, in a treatment of five hours did not kill boll weevils covered by from 6 to 10

inches of cotton seed. The failure of a heavy application of the gas to kill house flies covered by from 6 to 12 inches of seed in five hours shows the great resistance of bulk cotton seed to the uniform diffusion of hydrocyanic acid gas. It was consequently considered that there was not a promising outlook for this gas on account of its very slight penetrating power, and attention was directed to carbon bisulphid.

Experiment with carbon bisulphid in box of 15.88 cubic feet capacity.

Rate of CS_2 per 1,000 cubic feet.	Distance of weevils from surface.	Time.	Results.
Pounds.	*Inches.*	*Hours.*	
1½	8 to 10	24	Alive.
1½	12	24	Do.
3	8 to 10	24	Do.
3	12	24	Do.
3	6	24	Dead.
3	12	24	50 per cent alive.
4	8 to 10	24	Alive.
4	12	24	Do.
5	8 to 10	24	50 per cent alive.
5	12	24	Alive.

This experiment was performed in a tight box, in which were placed sacks of cotton seed containing weevils in perforated tin boxes buried at varying depths, as in the preceding experiment. The amount of carbon bisulphid used was varied from 1½ pounds per 1,000 cubic feet, a rather heavy application for the destruction of insects in stored grain, to 5 pounds per 1,000 cubic feet. It will be noted that the insects covered by 10 or more inches of seed were not killed in twenty-four hours, even with the heaviest application. However, it was considered advisable to verify these results by another experiment, as follows:

Experiment with carbon bisulphid in cylinder 70 inches long.

Rate of CS_2 per 1,000 cubic feet.	Distance of weevils from surface.	Time.	Results.	Remarks.
Pounds.	*Inches.*	*Hours.*		
3.0	6	24	Dead	
3.0	64	21	Alive	House fly killed.
7.3	36	37	Dead	
7.3	64	37	Alive	
10.0	36	21	Dead	
10.0	54	21	Alive	Do.
10.0	64	21	.....do	Do.

This experiment was performed in an upright, gas-tight, galvanized-iron cylinder 70 inches long by 12 inches in diameter, in order to obtain conditions similar to those existing in the case of cotton seed stored in bulk or in bins. The carbon bisulphid was placed in a shal-

low dish on top. Both the top and bottom of the cylinder were provided with leather packing and covers which were screwed on tight. The weevils were inclosed in perforated boxes as in the preceding experiments. The results show the failure of the gas, when applied at the rate of 10 pounds to 1,000 cubic feet, to penetrate sufficiently to kill weevils buried beneath 4½ or more feet of seed. At 3 feet, however, 7.3 pounds per cubic foot killed the insects. That small quantities of gas penetrated the full depth of the cylinder is shown by the death of the house flies.

These experiments seemed to indicate the futility of the use of carbon bisulphid in an unvolatilized form, and it was therefore determined to test it in an artificially volatilized form, as shown in the following experiments. Credit for this idea should be given to the writer's principal assistant, Dr. W. E. Hinds, who has experimented extensively with carbon bisulphid.[a]

Experiment with carbon bisulphid volatilized artificially in cylinder 70 by 12 inches.

Rate of CS_2 per 1,000 cubic feet.	Distance of weevils from surface.	Time.	Results.
Pounds.	*Inches.*	*Hours.*	
4	48	24	Dead.
4	64	24	Do.
5	48	15	Do.
5	64	15	Do.
10	36	16	Do.
10	54	16	Do.
10	64	16	Do.

In this experiment, by means of special apparatus, a current of air was passed through the liquid carbon bisulphid and the resulting vapor was driven through connecting tubing into a section of iron gas pipe which could be forced through the seed to the bottom of the cylinder, and which was gradually withdrawn during the application. The diffusion of the vapor under pressure through the mass of seed was very rapid and, as will be noted by a comparison of the two last tables, the amounts of carbon bisulphid used were far more efficient.

This experiment was followed by a number of others in forcing the gas into the seed in 100-pound sacks. It was found quite practicable in this way to kill the weevils contained at any point in the sacks, providing the carbon bisulphid was used at the rate of 8 pounds per 1,000 cubic feet and left for forty hours.

MEANS AND METHOD FOR SUCCESSFUL FUMIGATION OF COTTON SEED.

The following plan for this work is proposed: A tight matched-board box should be provided having sides 4 feet high, open on top,

[a] See Farmers' Bulletin No. 145, U. S. Dept. of Agr.

and of other dimensions to accommodate 12 or more 100-pound sacks of cotton seed placed upright upon the bottom. Another tier of sacks could be added if desired. Into each one of these sacks about 1 ounce of carbon bisulphid should be forced by an apparatus for volatilizing the liquid and mixing the vapor with air. The accompanying illustration (fig. 1) will give an idea of this apparatus. It should consist of

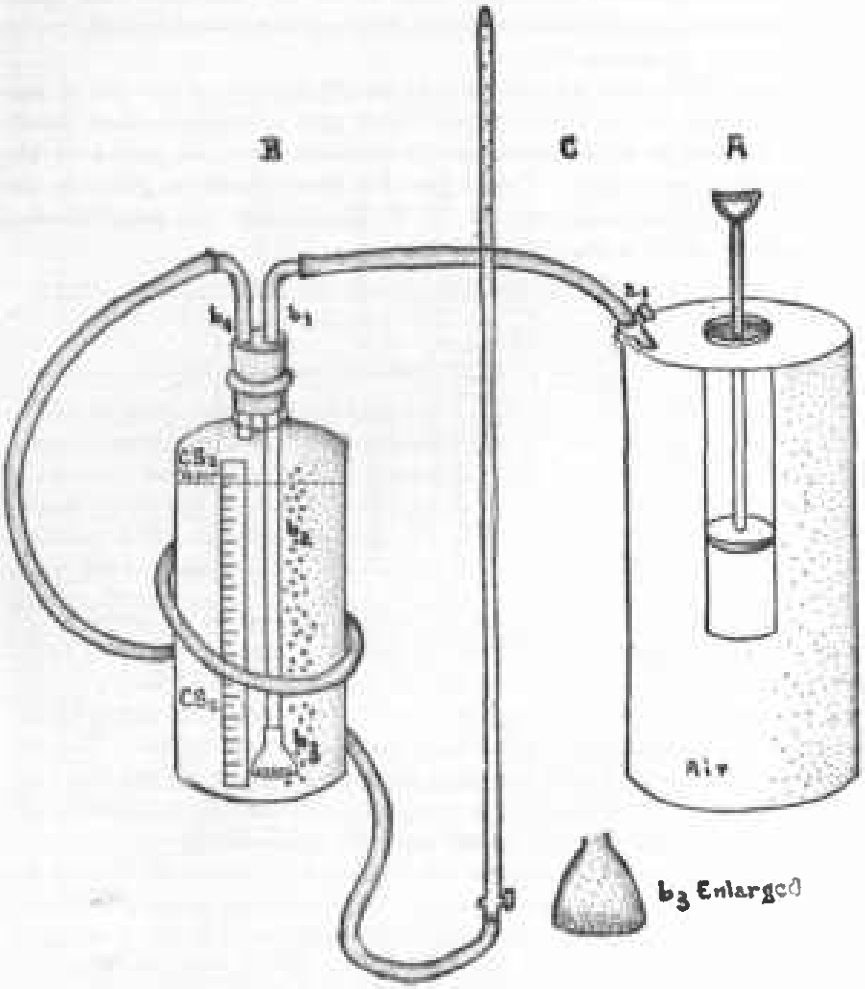

FIG. 1.—Apparatus for fumigating cotton seed in the sack. (Original.)

three essential parts, as shown in the illustration. *A* is an air pump having sufficient storage capacity to enable it to maintain a steady discharge of air for several minutes without continuous pumping. The stopcock at a^1 regulates or prevents the escape of air, as may be desired. *B* is an ordinary 2-quart bottle, fitted at b^1 with a tight

stopper of good length, having two openings, through which the inlet and outlet pipes pass. These pipes may be of glass or metal and should be as large as can be used. The inlet pipe, b^2, reaches nearly to the bottom of the bottle and is provided at the lower end with a perforated metal cap as large as will pass through the neck of the bottle. This allows the escape of the air in small bubbles and insures rapid evaporation. The outlet pipe, b^1, reaches only through the stopper. Upon the outside of the bottle is pasted a paper marked with 1-ounce graduations. *C* is a piece of ordinary $\frac{3}{8}$-inch iron gas pipe about $3\frac{1}{2}$ feet long, but this may be any desired length. It is closed and roundly pointed at the tip, and for about 15 to 18 inches of its length provided with small perforations pointing in all directions to give free escape to the vapor into all parts of the sack of seed at once.

The connections may be of rubber tubing, but as little rubber as possible should be used for this apparatus, as it is affected by the vapor of the bisulphid, and the couplings will have to be frequently replaced. This, however, will not be a considerable item of expense. With the apparatus just described, one operator would be able to accomplish the entire work of disinfection. The amount of carbon bisulphid recommended is about 1 ounce for each 3-bushel sack. It is safe to say that this can be secured for less than 1 cent per ounce when purchased in 25 or 50 pound lots, making the cost of bisulphid not over 1 cent per sack. As it requires but from two to three minutes to vaporize 1 ounce of the liquid in the manner described, the expense for labor in application would not amount to one-half a cent per sack. Fumigation with carbon bisulphid can therefore be effectively made at the slight expense of from 1 to $1\frac{1}{2}$ cents per 100-pound sack.

Application of the bisulphid in this manner reduces the elements of danger to a minimum, as the vapor is almost wholly confined and the slight quantity escaping, mixed with the open air, would not be in either inflammable or explosive proportions. It has been determined that the slight trace of bisulphid vapor in the air would not injure the operator in the slightest degree. The sacks should be left in the box for forty hours after the gas is injected.

SUMMARY OF RESULTS OF FUMIGATION EXPERIMENTS.

I. The fumigation of cotton seed in bulk offers many difficulties. The adhering lint seems to form a dense mass very impervious to the commonly used fumigants. Moreover, the boll weevil seems unusually resistant to these agents.

II. At present it does not seem possible to use hydrocyanic acid gas. Especially susceptible insects, like house flies, when protected by from 6 to 12 inches of seed, are not killed within five hours by a gas resulting from the use of 0.5 gram of potassium cyanide to the cubic foot.

III. Carbon bisulphid allowed to volatilize naturally is of little use. At the rate of even 10 pounds per 1,000 cubic feet it will not kill weevils buried beneath 4½ feet or more of seed. At the rate of 4 pounds per 1,000 cubic feet simply poured into a 100-pound sack it will not always kill the weevils at the bottom. It is consequently useless in this way for the fumigation of seed in large bulk.

IV. When volatilized artificially, however, carbon bisulphid may be used successfully in destroying the weevil in sacked cotton seed by means of a comparatively cheap and simple apparatus. Every farmer living in an uninfested region who obtains cotton seed from infested parts should insist that it be fumigated in this way. The introduction of the weevil into foreign countries could be prevented in the same way.

CONTROLLING THE BOLL WEEVIL AT GINNERIES.

On account of the great difficulty of destroying the boll weevils by means of the fumigation of the bulk seed, which was demonstrated by the foregoing experiments, the Department has concerned itself especially with an investigation to determine whether or not it is possible to prevent the dissemination of the pest through the agency of gins. The services of an especially trained gin expert, Mr. James Hull, who has been actually engaged in the ginning business in Texas for fourteen years, were obtained. He has made a careful study of all the various systems of ginning cotton in this country, with special reference to the boll weevil. The suggestions offered in the following pages are based upon his work. They have, moreover, been brought to the attention of representatives of the principal ginning systems for suggestions as to their practicability. Circulars have been addressed to the 11,000 ginners in Texas and Louisiana in order to obtain an exact knowledge of the various systems and combinations in use, in order that the Department's suggestions may not be out of place in view of the machinery that is in actual use.

EXPERIMENTS TO DETERMINE EFFECTS OF MACHINERY ON LIVE WEEVILS IN SEED COTTON.

In addition to the foregoing basis for this report, a modern gin has been run experimentally to determine several previously unsettled points regarding the exact places in the system of ginning and handling cotton through which the weevils may escape. The first of these experiments was made to determine whether the weevils could pass alive through the main fan in a pneumatic elevator system. Several hundred live weevils, marked with colored pencils in such a manner as to be easily recognizable, were fed into the suction tube between the gins and the fan, after a large bag about 2½ feet in diameter and 16

feet long had been tied over the mouth of the discharge pipe in the car standing on the sidetrack. In this partienlar instance the fan was of 44-inch size and was run at 1,800 revolutions per minute. A careful examination was made of the contents of the bag, but it was found that no weevils passed through alive. The weevils were cut into small fragments by the swiftly revolving blades of the fan.

A second experiment was designed to determine whether weevils might pass through the gin itself when in actual operation. One hundred and fifty marked live weevils were fed directly into the outer roll of an 80-saw gin, revolving at the rate of 400 revolutions per minute. The first seed, run through in about one minute, was collected and examined separately. Then the whole roll was thrown out after about two minutes. The mote dust was also collected and examined. The seed run out during the first minute yielded 47 marked weevils alive and 3 marked weevils dead. The main bulk of the roll contained about 15 times as much seed as collected in the way just described. It yielded 40 marked weevils alive and 5 marked weevils dead. The mote collection yielded 10 marked weevils alive and no marked weevils dead. The total number of marked weevils collected in this experiment was 105; the percentage of marked weevils recovered was 70; the percentage of recovered marked weevils alive, 92.4, and the percentage of recovered marked weevils dead, 7.6. A number of unmarked weevils which had evidently passed through the pneumatic feeder to the gin breast were found in the course of this experiment. They are, of course, omitted in the above figures.

This experiment, which was repeated at different times, demonstrated that in actual ginning weevils escape from the gin at two points, one with the seed into the seed chute and the other with the motes at the mote board.

The following experiments demonstrated the fact that in addition to the two avenues of escape that have been mentioned weevils also pass through cleaning feeders, in many cases without being injured. A lot of 200 live weevils, marked as above described, was run through a modern cleaner feeder, consisting of fluted rollers, picker roller, and the accompanying screens. In this case the picker roller was run at about 170 revolutions per minute. The weevils were fed into the top of the cleaner feeder at the point where the cotton becomes dead. The trash from the spiral conveyor tube was collected for about ten minutes, as was also the seed discharged by the gin during that time, in addition to the motes. Results: Marked weevils extracted by cleaner feeder, alive 54, dead 7, total 61; in the seed thrown out, marked weevils alive 6, dead 5; among the motes, marked weevils alive 9, dead 5; total marked weevils found, 86, or 43 per cent of those put in. As in the preceding experiment a number of unmarked weevils were found.

Considering the total (including unmarked weevils) of 124 weevils found, the cleaner feeder separated 71 per cent of the total number. Weevils in the seed numbered 16, or 13 per cent of the total found. In the motes 20 weevils were found, or 16 per cent of the total. Among 88 weevils from the cleaner feeder 83 per cent were alive. Among 16 weevils from seed 56 per cent were alive. Among 20 weevils from motes 55 per cent were alive. Fifty-seven per cent of the marked weevils could not be accounted for.

Summary of experiments in passing weevils through gin machinery.

Nature of experiment.	Method of recovery.	Number of marked weevils used.	Found alive.		Found dead.		Per cent lost.
			Number.	Per cent.	Number.	Per cent.	
Passage through fan only.	Blown on sheets spread in seed house.	105	0	.....	30	29	71
Do.....	Bunting bag at discharge in car.	100	0	.....	90	90	10
Passage through saws only.	Seed caught on floor. No motes.	50	19	38	10	20	42
Do.....	Seed caught on floor. Motes examined.	150	97	64⅔	8	5⅓	30
Through cleaner feeder and motes.	Trash and motes[a] collected and examined.	250	85	34	9	3.6	62.4
Through cleaner feeder and saws.	Trash,[b] motes, and seed collected and examined.	200	69	34.5	17	8.5	57

[a] Of 94 weevils (dead and alive) recovered, 13 (10 dead and 3 alive) were at mote board.
[b] Of 86 weevils (dead and alive) recovered, 11 were found in seed, 14 in motes, and 61 in trash from cleaner feeder.

WHAT THE EXPERIMENTS HAVE DEMONSTRATED.

From the above-described experiments and many observations it has been demonstrated that seed cotton carried by the powerful suction of the fan may strike directly against the wire-screen separator and the weevils contained may not be injured in the slightest degree. These same weevils may be again taken with this same seed cotton from the storage house and driven against another distinct wire-screen separator in the pneumatic system. Thence they may pass down through the screens at the rear of the picker roller in the cleaner feeder and may be carried along with other foreign substances separated from the seed cotton by the screw conveyor connected therewith. In case the insects pass through the screen in the pneumatic elevator chute they pass through the main fan and are killed. In case, however, they are not separated from the cotton by the picker roller in the cleaner feeder they may pass through the saws of the gin with the seed into the seed chute, or drop with the motes from the mote board.

PRESENT SYSTEMS OF HANDLING AND GINNING SEED COTTON.

In the following pages, practically all of the methods of handling and ginning seed cotton in use in the United States at the present time will be discussed, with a view to pointing out the weaknesses of the

several systems in regard to destroying or controlling the boll weevils. The matter is a rather complicated one, owing not only to the diversity of the different systems of ginning the staple, but the frequent combination in one plant of parts of those different systems. Moreover, there is at present considerable activity in the improvement of ginning machinery, resulting in frequent important changes. This discussion, however, will enable any ginner, no matter what his system, to learn the exact point at which the weevils escape, and will consequently show him in what manner the danger of disseminating the pest may be avoided. Moreover, several new suggestions in regard to special cleaners are made in the following pages, and it is hoped that manufacturers and ginners will be able to make use of them.

HAND SYSTEM AT SEED-COTTON STORAGE HOUSE.

This class of storage house is used principally in localities where ginning for custom is done exclusively, where farmers desire to bring a portion of a load of cotton at a time, allowing it to accumulate until it amounts to a bale or more, and at large ginneries during the latter part of the season when the gins are not running full time. The seed cotton is placed in bins without any special machinery whatever. At gins where the seed cotton is unloaded by this system it appears that all boll weevils must pass with the seed cotton into the gin house. The ginner must therefore depend upon devices in the gin house proper, to be described later, for separating weevils from the seed cotton. It is therefore unnecessary to enter into details of unloading seed cotton by hand. We may take up the more modern systems of unloading by mechanical devices, which keep the boll weevils under more or less control.

CARRIER SYSTEM OF UNLOADING SEED COTTON INTO STORAGE HOUSE.

This system consists of an endless apron running from the wagon to the bins. It was in use previous to the advent of the more modern method of blowing seed cotton to the storage house or to its various compartments. As far as the control of the boll weevil is concerned it does not differ from the hand system.

SUCTION SYSTEM OF CONVEYING SEED COTTON FROM WAGON TO STORAGE HOUSE.

This system can be conveniently presented under three heads: (1) With safety fan; (2) with one fan and vacuum box; (3) with two fans and vacuum box.

With safety fan.—In the safety-fan system the seed cotton is drawn from the wagon by suction, and is separated from the air current by a screen within the fan. The blast from the fan is used to blow the

seed cotton into any desired portion of the storage house. In this system, a few boll weevils may be killed by striking against the screen. Those that pass through the meshes of the screen are forced through the fan, where they are undoubtedly destroyed. It is safe to say, however, that the majority will pass along with the seed cotton.

With one fan and vacuum box.—According to the second plan an ordinary fan is used. The seed cotton is drawn from the wagon by the suction of the fan, and separated from the air inside the vacuum box by means of a wire screen. The balance of the operation is the same as in the preceding case, except that a sand pocket is provided at the rear of the screen, thus allowing a large portion of the débris to fall into this chamber, where it is prevented from passing through the fan. The accumulated débris is usually cleaned out at frequent intervals and thrown about the gin yard, liberating any weevils that may have passed through the screen, as in the preceding case. Though some weevils may be killed by the action of the fan, the great majority of them pass along with the seed cotton.

With two fans and vacuum box.—According to the third plan, the vacuum box provided, as in the preceding case, is connected with two ordinary fans, the first of which is used for suction and the second for blowing the seed cotton into any desired portion of the storage house. From the standpoint of controlling the boll weevil this arrangement has no special advantage over the preceding one.

The vacuum box is frequently used as a cotton dropper. In such cases the seed cotton is dropped directly into a feeder standing beneath it. If this feeder were fitted with the cleaning attachments, to be described later, an excellent means would be provided for destroying many of the weevils that would otherwise pass to the cotton-seed storage house.

Special droppers.—In addition to the above-described system, some concerns manufacture special droppers which pass the seed cotton over a large screening surface before it becomes dead and falls upon the floor or is blown into compartments. The débris, which may include weevils, extracted during the movement of the seed cotton over the screen, passes through the fan, by the action of which the insects would undoubtedly be destroyed. Such devices are useful in reducing the number of weevils in the seed cotton before it reaches the gin house proper, but none of them can be depended upon to eliminate all of the weevils. Their work would be much more effective if they were provided with beaters, or a series of beaters, to throw the seed cotton against the screen, thus separating every one of the locks. Undoubtedly one of the most important suggestions to be offered is that more extensive use be made of these devices. The more seed cotton can be agitated, the greater the probability that the

weevils will be removed, and when the débris is passed through the fan, there is no probability that any insects will escape alive.

HAND AND BASKET METHOD AT GIN HOUSE.

In this system the seed cotton is unloaded directly from the wagons into baskets and placed in the feeder. The feeding is accomplished by the movement of an inclined carrier belt which moves the cotton forward and against the picker roller which separates the locks and drops them directly into the gin breast. A considerable amount of sand, gravel, and in many cases weevils, is separated from the seed cotton and dropped either directly upon the floor or into the trash box at the lower portion of the hopper. As a rule the trash, including weevils, is thrown into the seed conveyors, whence it reaches the seed boxes or cars. It will be readily seen that weevils are practically unrestricted by this system, although the collection and destruction of the trash instead of returning it to the seed would eliminate a large number of them. The hand and basket method of feeding the gins is in use at nearly 9 per cent of the ginneries in Texas and at 44½ per cent of those in Louisiana.

PNEUMATIC SYSTEM WITH BELT DISTRIBUTORS.

In this system the seed cotton, either from the wagon or the storage house, is drawn by suction from the fan or driven by a blower against a wire screen. The fan or blower is placed in various positions in the gin house. The wire screen in the separator is the most essential part of the apparatus. Its use is to separate the dirt from the seed cotton and to prevent the seed cotton from passing through the fan and being discharged either into the open air above the building or below into the receptacles for seed. Some manufacturers have provided a box for catching the trash at the rear of the screen or beneath the distributor belt. The seed cotton is dropped upon the distributor belt and deposited in hoppers and open feeders resting horizontally upon the gins. The amount of seed cotton fed upon the belt is to some extent uncontrollable. When all the hoppers are filled a surplus accumulates. This surplus seed cotton drops upon the floor and is from time to time drawn up by suction into the vacuum box or separator, whence it again reaches the distributor belt.

In the distributor-belt system the seed cotton is dropped into an open feeder, which is a convenient term for differentiating feeders used with this system from those used with the pneumatic system, in which all seed cotton and mechanical devices for cleaning it are entirely inclosed. There are many different styles of these feeders, but the essential point for the present purpose is that they are all open. The

bottom of the hopper of these feeders consists of an endless movable apron which carries the seed cotton forward and against the picker roller or spiked drum which separates the loose locks and deposits them in the gin stand. In this class of feeders all of the trash, boll weevils, immature locks of cotton, etc., which does not fall through the picker roller is carried with the seed cotton and falls directly into the gin breast. At the present time it may be safely stated that nearly all the residue which falls between the spikes of the picker roller is swept from the top of the gins and deposited in the seed conveyor, through which it is blown or otherwise conveyed into the seed storage house, cars, or farmers' seed boxes. The spread of weevils is facilitated by the use of this class of open feeders with the distributor-belt system, though the apparatus as in use at the present time has considerable advantage over the hand and basket system. The principal advantage is that the seed cotton is elevated by suction and beaten directly against the separator screen, where a certain number of weevils may be killed. That the number thus killed or removed is small has been proven by many observations. An important suggestion in connection with these open feeders is that a receptacle should be furnished for catching the débris which falls from the picker roll. This trash could easily be carried to any desired point by a spiral conveyor.

The most important weakness in the belt-distributor system is found in the overflow that accumulates on the floor at frequent intervals. Many weevils in the seed cotton thereby have a chance to escape to any part of the ginhouse. This danger is obviated altogether in the system next to be described.

It is needless to state that from the ginner's standpoint, manufacturers have obtained perfection in this system. The present objection could be obviated, to some extent at least, if the overflow from the distributor belt were fed into a weevil-proof box or bin, whence it might be re-fed directly into the gins or into cleaner feeders connected therewith. There are, no doubt, mechanical difficulties to be overcome in making this change, but at present it appears that they are not insurmountable.

PNEUMATIC SYSTEM WITH CLEANER FEEDERS.

This system has the decided advantage over the pneumatic system with distributor belt that there is no overflow, and all weevils that are in the seed cotton must be deposited within the feeders.

A great deal of ingenuity has been used in the construction of the feeders considered under this head, but the principles upon which they operate are very similar. In Texas 33⅓ per cent and in Louisiana 19⅛ per cent of the ginneries are provided with these feeders.

Use of the cleaner feeder.—In these machines the seed cotton is drawn through tubing to the pneumatic elevator resting directly upon the

feeder itself, which in turn rests upon the top of the gin stand. The seed cotton is separated from the air current by the screen, where it becomes dead and drops into the closed hopper, the mass passing gradually between fluted rollers, from which it is received by a picker roller making about 170 revolutions per minute. As each lock of cotton reaches the picker roller it is revolved many times, being beaten against a curved screen which has generally a clear opening of one-third of an inch. It is then discharged directly into the breast of the gin stand. The screen and all other parts mentioned are inclosed in tight casting, so that the weevils that may be contained in the seed cotton must either be removed by the action of the picker roller upon the screen or pass with the seed cotton into the gin breast. As is shown on page 14, about 70 per cent of the weevils are separated by the cleaner feeder and about 30 per cent pass into the gin, from which they are thrown out either with the seed or with the motes. In case they pass through the screen with the general trash, they fall directly upon the spiral conveyor, which is continuous from one end of the battery of gins to the other, and are discharged into a spout leading to a trash receptacle, usually placed below. In plain feeder gins, however, as has been noted, this trash is either deposited at the rear of the gin, or is carried to the seed conveyor through which it is blown or carried with the seed to the cars or seed house as may be desired. To summarize, with the pneumatic and cleaner feeder system, there are three avenues for the escape of the boll weevils.

(1) Any specimens that may be drawn by the suction of the fan through the screen above the hopper would have to pass through the fan, which ordinarily makes from 1,500 to 2,000 revolutions per minute. Experiments have proven that they are killed under such circumstances.

(2) Any weevils that remain in the seed cotton as it is driven by the revolving picker roller against the screen at the rear will pass with the seed cotton directly into the breast of the gin and upon the roll of seed cotton which is rotating at all times during the operation of ginning. After reaching this situation, they may pass along with the seed into the seed conveyor, or be thrown out at the mote board, or pass with the lint to the baling machinery, as has been proven by experiments, the details of which have been given in preceding paragraphs.

(3) All weevils separated from the seed cotton by the action of the picker roller in beating against the cleaning screen must be confined to the space below the screen. As there is no other avenue of escape, they must fall upon the spiral conveyor and thus be carried to the outer end of the battery of gins, where, as before stated, with most gins, all the trash is conveyed through a spout leading directly into the seed conveyor.

On account of the weevil's habit of becoming quiet when disturbed, it has been found that there is little danger of individuals that have been fed into the spiral conveyor crawling out before the trash is deposited. This slight danger may be partially obviated by simply covering the conveyor box between the gin stands, so that the only openings into it will be within the screening chamber, and the only outlet will be at the spout leading to the trash receptacle.

Apron cleaner feeder.—This cleaner feeder is designed for use with the basket system of feeding at small ginneries, and also with the distributor-belt system. All the trash, including the weevils, which falls from the revolving apron drops directly upon a spiral conveyor and becomes mixed with the trash removed by the picker roller, beating the seed cotton against the screen beneath it. Both weevils and trash are carried through a pipe at the end of each gin and discharged into the seed conveyor, or a box placed below or upon the floor. In these cleaners the screw conveyor is the length of one gin stand only, and is not connected through a full battery of gins, as is the case with the ordinary cleaner feeder previously described. In order to make it accomplish the same result as in the upright cleaner feeder, it would be necessary to convey the trash through spouts from each separate gin, leading, at the rear of the battery of gins, into a spiral screw conveyor, which would carry the trash to any point desired. This spiral conveyor should discharge between compression rollers, or other devices which could be easily provided, whereby all insects reaching them would be destroyed. This method of destruction will be detailed more fully in the recommendations.

Special cleaner feeders.—In addition to the ordinary and apron cleaner feeders, which have been described, special forms are now manufactured by some companies, and there seems to be considerable activity in improvements in this line of ginning machinery. In some cases these devices combine elevating, cleaning, distributing, hulling, and feeding operations. In the ordinary cleaner feeders the seed cotton is drawn by the suction of the fan and separated from the current of air by a screen. The cotton usually strikes the screen in a more or less compact body, so that comparatively few weevils are driven through this screen. In the improved systems, however, the seed cotton falls directly upon a revolving beater, which drives it against the screen and separates the locks thoroughly. In some cases the cotton is then passed on to another beater, revolving against a similar screen, thus giving it two thorough workings. As the full force of the air passes through these screens, all boll weevils and trash, separated by the combined beating and screening operations, are passed through the fan and thereby destroyed. In one form of feeder, in addition to the two beaters, a picker roller is used, and below that a

huller feeder leading to the gin itself. In connection with the picker roller is a trash flue, and in connection with the huller there is a spiral conveyor for such trash as may have escaped the preceding operations. There can be no doubt that this system is very effective in extracting the weevils from the seed cotton and destroying them. From the present standpoint, however, these machines have the weakness of requiring a belt distributor, because of the fact that the air passes through the screens before the cotton reaches the lower portion of the device. As has been pointed out previously, there is great danger of the weevils escaping and spreading from the surplus which the belt distributor deposits upon the floor of the gin. However, in this case, the very thorough beating and screening through which the cotton has passed undoubtedly largely removes this objection. Although no actual experiments have been performed, it seems certain that practically all of the weevils will be extracted from the seed cotton before it reaches the belt distributor. This system undoubtedly constitutes one of the most thorough cleaning devices for cotton now known.

SEPARATE CLEANERS.

Considerable ingenuity has been exercised in perfecting another class of cleaners, which are separate machines and movable from one point in a ginnery or seed-cotton storage house to another. They are used either in connection with the distributor-belt system at the gin or in the seed-cotton storage house for simply dropping the cotton, or blowing it into stalls or compartments. These machines consist of a picker roller or drum, revolving rapidly against a screen. The débris passing through the screen, which would include many weevils, is drawn through a fan and discharged at various places. These machines have superior merit for cleaning the seed cotton, as they have a very large arc of contact on the screening surface. The speed at which the picker roller is revolved, greatly exceeding that attained in the case of the ordinary feeders, is another decided advantage. The weevils forced through the meshes of this screen are carried through the fan, where experiments have shown that they will be destroyed. It is consequently immaterial whether the trash is blown about the gin yard or into the seed conveyor, as is sometimes done. Unfortunately these excellent machines are not likely to come into general use at the large ginneries for the reason that the seed cotton in passing from the wagon to the bale would have to be rehandled and refed through another suction pipe leading to the gins. The modern cleaner feeders seem to be taking the place of nearly all separate and distinct cleaning devices at the gins. Nevertheless, where seed cotton is taken from the wagons in baskets and fed into the gin stands these machines would be of very decided advantage in eliminating the weevils.

In addition to the various cleaners already described, an entirely distinct machine is now made to be interposed between the cotton supply and the type of pneumatic elevator, the apparatus forming a section in the supply pipe. This machine is, however, also used as a separate and independent cleaner, which may be moved to any place in the ginnery. In either case the seed cotton is beaten against a cylindrical screen, being manipulated in such a way as to become practically dead when it falls upon the beaters. The action of the arms of the beaters carries it through the apparatus, giving it constant agitation against the screening surface, which in this cleaner is far greater than that used in any other type. The weevils and other débris escaping through the meshes of the screen fall onto a spiral conveyor below, which carries them to any point desired. By passing the discharge through a pair of compressed rollers all weevils would be destroyed, and it would then be immaterial whether the trash were returned to the seed or deposited elsewhere. There seems no doubt that this system would be exceedingly effective in removing and destroying the weevils.

GINS.

There are two principal classes of gins in operation in the United States, known, respectively, as plain and huller gins. In addition to these the roller gin is used principally in sections where Sea Island cotton is produced, and a modification of the saw gin, known as the needle gin, may eventually come into quite extensive use. The avenues of escape of boll weevils from the ordinary saw gins have been described in the preceding pages. In Texas 93 per cent and in Louisiana nearly 42 per cent of all the gins are of this type.

The huller gin.—The huller gin is used particularly in sections where, owing to labor conditions or other causes, the usual care can not be observed in picking, and consequently more or less of the bolls, boll hulls, and other trash are gathered with the cotton. This gin is supposed to yield a better sample from trashy cotton than can be obtained from the plain gin, and seems to be growing in popularity. With the huller gin the seed cotton is fed into the outer breast, where it drops upon a rapidly revolving huller roller which carries it to the saws. The hulls, bolls, etc., are stopped by the projection of the ribs, while the seed cotton is carried by them into the inner breast, where it is ginned. With the case of the huller gin, it seems likely that more weevils will be deposited in the seed than is the case with the plain gin, on account of the fact that they are allowed to drop with the trash into the seed without going through the saws, as is the case in the plain gin. It seems certain, therefore, that the spread of the weevil must be greater with the open feeder and the huller gins than with the open feeder and the plain gins. Nevertheless, there would be no

difficulty in passing the seed cotton through any of the numerous forms of cleaner feeders before it reaches the outer breast of the huller gin, and this would obviate entirely the objection that has just been mentioned. In Texas nearly 7 per cent of the gins are hullers; in Louisiana, 58 per cent.

The roller gin.—In roller gins the seed cotton is thrown into a hopper, whence it is drawn by friction between a grooved or corrugated roller, made of rubber, walrus hide, or some other substance, which presses against a knife. Various methods are used for removing the lint from the roller, as well as for striking the seed from the lint as it is drawn against the knife by the action of the revolving cylinder. It seems likely that in this system some of the weevils would be killed by the doctor knife or by the beater knife used to remove the seed. Nevertheless, a large percentage of them would necessarily pass along with the seed and be conveyed to the seed house. There would be no difficulty in using cleaner feeders to deposit the cotton in a hopper, although special contrivances would be necessary on account of the slow rate at which the cotton is usually ginned by this process. A large portion of the effectiveness of the cleaner feeders is due to the rapidity at which the spiked roller revolves. This would probably result in feeding a heavy surplus into the hopper. It would be an easy matter, however, to arrange a storage for the surplus. The cleaner feeder might be stopped while the surplus is being ginned.

The needle gin.—The needle gin is simply a huller gin with a system of needles set upon a cylinder instead of saws. For the present purposes it is not essentially different from the ordinary huller gin.

HANDLING COTTON AFTER GINNING.

Between the gin and the baling apparatus the lint is handled by two separate systems, the open-condenser system and the lint-flue system.

Open-condenser system.—In the open-condenser system all of the lint from each gin drops directly upon the floor. When a sufficient quantity has accumulated to make a charge it is drawn along on the floor by hand or forks and deposited in the press. During this treatment weevils in the lint, of course, have abundant opportunities for escape. The condenser itself consists of a circular wire or perforated screen drum inclosed in a framework of iron, wood, canvas, or other material, leaving sufficient space to allow the escape of air, dust, etc., from the gin stands. In some cases there is an opening through the floor through which the air escapes, while in a battery of two or more gins the air discharges through double dust and air flues through the roof of the building.

The air-tight lint flue.—In modern ginneries, however, the open-condenser system is being done away with, and the air-tight lint flue

is used in connection with the battery of gins having one large condenser. In this system the weevils have no opportunity to escape from the lint between the gin and the baling apparatus. There follows naturally the suggestion that wherever possible the inclosed lint flues should be used, thus allowing no avenue of escape for the weevils, which must pass through the large condenser and there drop directly into the press.

SUGGESTED IMPROVEMENTS IN DEVICES FOR HANDLING AND GINNING COTTON.

From the preceding accounts it will be seen that many of the devices that have been perfected for cleaning cotton, and thereby improving the sample, are incidentally of great value in eliminating the boll weevil, although none of those tested have been found to be perfect. The following recommendations look toward the modification of these devices in such a way as to increase their efficiency. As the general trend in cotton ginning is toward improving the sample, and as these suggested modifications also accomplish that result, they should be considered carefully by all ginners.

IN THE SEED-COTTON STORAGE HOUSE.

At many of the smaller gins throughout the country the ginhouse and seed-cotton storage houses are combined under one roof. This is the case at 5¼ per cent of the ginneries in Texas and at 11⅛ per cent of those in Louisiana. Many of these buildings have no partitions, the seed only being kept as far from the seed cotton as possible. Although it is understood that in many cases it would not be possible for small ginners to provide separate houses for storing the seed cotton and the cotton seed, nevertheless in some cases it could be done without special inconvenience. It is very evident that where weevils are present the combination of the three houses under one roof is not advisable.

Where the seed cotton is unloaded by hand directly from the wagons into the storage house nothing can be done to destroy the weevils that are brought in with the seed cotton except by the installation of one of the various forms of separate cleaners or droppers. During the latter part of the ginning season a great deal of seed cotton is handled by hand, even at large ginneries, and does not pass through any machinery in the seed-cotton storage house. In such cases it will be necessary to pay particular attention to methods of eliminating the weevil in the ginhouse proper by means of cleaner feeders, cotton cleaners, separators, etc. In all seed-cotton warehouses where elevating pipes are used for receiving the cotton from the wagon and discharging it directly into the room below, or for blowing the seed cotton to different compartments, the most important feature is the

separator itself. This is a perforated wire screen which prevents the seed cotton from passing through the fan. At this separator an effective apparatus for cleaning the seed cotton should be introduced in order to force the weevils that may be removed through a fan. This end might be attained by providing beaters or spiked picker rollers, revolving as closely as possible to the wire separating screen, having the meshes opening one-third of an inch in the clear. The screening surface should be as large as possible. The picker rollers or beaters should run at a high rate of speed. Under these circumstances the suction of the fan would draw out the great majority of the trash which would pass through the fan, thus causing the destruction of the weevils. There is no doubt that the number of weevils could be very materially reduced by such contrivances, which are now manufactured, although it is not possible that all weevils could be eliminated in this way.

Some additional horsepower would be necessary, by reason of the rapid running and extra machinery here recommended. However, it is probable that not more than one additional horsepower would be required. The great majority of the gins undoubtedly have one or more horsepower to spare; still in some cases the lack of a surplus would interfere with the adoption of this recommendation.

IN THE GINHOUSE PROPER.

From the foregoing pages it will be evident that while some of the systems of handling the cotton in the ginhouse proper are more or less effective in eliminating the boll weevil, none of them are absolutely so. The most defective of the mechanical devices are found with the plain feeders, front plain feeders, and huller gins, in connection with the handling of the seed cotton by hand or by distributor belts. In such systems all trash, sand, boll weevils, etc., fall directly to the top of the gin stands or to the floor, or directly into the seed conveyor, whence the weevils may easily reach the seed house.

On the other hand, many of the modern cleaning feeders and cotton cleaners have valuable features as far as the control of the boll weevil is concerned. They confine all of the trash removed in spiral conveyors, where it is under perfect control. The trash from the battery of gins should be carried through a single spiral conveyor, which should be closed between the gins. At the present time the usual method is to scatter this trash broadcast about the gin yard or to pass it into the seed conveyor and thence to the seed house. From this place the weevils that may be contained are frequently transported long distances in seed for planting purposes. It would be a very simple matter to pass all this trash from the battery of gins between two compression rollers made of either wood, iron, or other hard substance, having sufficient

strength to crush all of the weevils that might be contained. After that has been done it would be immaterial whether the débris was scattered about the gin yard or sent with the seed to the seed-storage house. The installation of the compression rollers would, therefore, not interfere with the trash taking exactly the same course as it does at the present time. It should be noticed in this connection that the very important point is in having the spiral conveyor continuous with the whole battery of gins and having only one outlet. With some of the cleaner feeders there are separate screw trash conveyors for each stand, situated under the front of the feeder. In such cases it would be necessary to carry the trash from the pipes that are generally provided into one continuous conveyor discharging at one end, where compression rollers could be applied in the manner that has been mentioned.

With the belt-distributor system, it will be necessary to provide a box for the overflow of seed cotton. If the seed cotton is scattered over the floor, the weevils can escape more freely than if dropped into this box. A better method, however, would be to provide, in connection with the separator and vacuum box, a complete cotton cleaner and separator combined. Thus the seed cotton would be practically freed from weevils before it is dropped upon the distributor belt.

With the present huller gins and plain feeders, the boll weevil is kept under less control than with plain gins. All live boll weevils which become loosened from the seed cotton while on the feeder roller necessarily fall down into the seed conveyor and pass out with the seed; with the plain gin, on the other hand, the seed cotton is fed directly into the breast or roller box of the gin, thus coming in contact with the saws immediately. However, this apparent objection to the huller gin could be entirely obviated by the placing of a cleaner feeder above the stand.

With the plain feeders now used the boll weevils are kept much less under control than with the modern cleaning feeders. The seed cotton is dropped upon an endless apron and conveyed against the picker roller, which separates the locks, elevates them, and deposits them directly in the gin breast. Hence all weevils not carried up and deposited directly in the gin breast, or with the huller gins in the outer breast, drop through the full width of this endless apron feeder upon the top of the gin stands and are there scattered in all directions. A practical suggestion concerning the elimination of this difficulty is in the attachment of a movable bottom sheet beneath the apron wherever this would not interfere with the operation of the gin. In some cases there might be difficulty on account of the small space between the revolving apron and the top of the stand. However, wherever a false bottom could be used, all of the trash, including the

weevils, could be made to slide directly into a continuous spiral screw conveyor at the rear of the gin stands. The screw conveyors for the separate gins could easily be made continuous, and the discharge from the full battery of gins could be passed through compression rollers at the end.

From the preceding paragraphs it will be seen that by the installation of cleaning droppers in the seed-cotton storage house and of special cleaners in the ginhouse proper, a great majority of the weevils could be brought under control. Nevertheless, with any of the devices that have been studied, it is apparent that a number of weevils reach the gin itself, and that a considerable percentage of these escape alive, either in the seed or at the mote board. These two avenues of escape illustrate the greatest weakness, as far as the boll weevil is concerned, of the various cleaners which are perfectly constructed for the objects the inventors have had in mind—i. e., simply removing the trash from the cotton. Further inventions may possibly bring about still further perfection in this system of cleaning cotton, but at present manufacturers should devote some attention to the construction of contrivances which will eliminate the weevils from the seed and motes. There would apparently be no insurmountable mechanical difficulties in causing the motes to run to the seed as it falls from the gin. If this could be done and the combined seed and motes could be cleaned by passing along screens in connection with some agitating device, like a picker roller, or over an oscillating perforated bottom, the weevils would be shaken below and there collected by a spiral conveyor and destroyed by means of a pair of compression rollers. It is believed that practically all of the boll weevils in the seed could be destroyed by these means. In case of the use of a screen and picker roller, at least where two fans are used in the elevating system, it would be an easy matter to obtain the desired suction, without involving any additional horsepower whatever. In case of the use of the oscillating bottom, the only additional horsepower necessary would be the very small amount required for causing the agitation and for running the compression rollers. Either device might easily be introduced between the seed chute at the gin and the blower, and would thus not interfere materially with the present course of the seed.

It will be seen that the advantage in conveying the motes to the seed, as suggested in this plan, is that the weevils from both may be extracted at one operation. However, it would be perfectly feasible to collect the motes independently by means of a spiral conveyor and to destroy the weevils contained therein by means of a pair of rollers.

It seems to the writer possible that suction alone might be utilized to separate the weevils from the seed as they are dropped from the saws to the seed chute. At this stage the seeds are thoroughly sepa-

rated, much more so than at any other stage of handling. An average cotton seed weighs about 2 grains, while an average boll weevil weighs only about one-eighth as much, or one-fourth of a grain. Between such extremes it seems feasible to adjust a suction pipe in such a manner as to remove the weevils. Possibly an air blast instead of suction might be used in forcing the weevils toward the motes, with which they might be collected and destroyed. The suction system, however, would have the advantage of furnishing its own device for destroying the weevils, namely, the fan itself, though in that case there would still be the necessity for a separate device for the proper manipulation of the motes. It is believed that the suction or blast could be obtained at the ordinary gin without an independent fan. There will, of course, be difficulties to overcome in constructing a device along the lines suggested, among them that of obtaining an even degree of suction or blast the full width of the seed chute, or for a possibly lessened width, into which the seeds might be brought. Nevertheless, the matter is undoubtedly well worthy of experimental trial.

The same results as those aimed at by the above-described system might be obtained by the use of sand reels, such as are used in oil mills, in connection with the separate gins, or one large reel for the reception of the combined discharge from the battery. Sand reels, however, are rather expensive machines, and require some additional horsepower. Their installation at gins is, therefore, considered much less practicable than the installation of some such device as has been suggested.

CONTROLLING THE BOLL WEEVIL AT OIL MILLS.

Under the present arrangements large numbers of weevils concentrated at the gins in the seed cotton reach the seed house, whence they are conveyed in cars or wagons to the oil mills. There are several avenues of escape at these mills. It has been demonstrated that cotton fields in the vicinity of oil mills which have received seed from infested territories become infested by the weevil sooner than others. The weevils liberated from the seed at the mills frequently get into by-products, particularly hulls, and have been known to be transported to barns when the hulls were carried from the mills for feeding purposes. With the present generally rather ineffective methods for controlling the weevils before the seed reaches the oil mill, control at the mill is scarcely less important than at the gin itself.

When the seed arrives at the mill, it is generally unloaded from the farmers' or ginners' wagons or cars directly into the storage house by hand, although in some cases screw conveyors are used for this purpose. However, after the seed reaches the storage house the methods

of handling it are identical. It is shoveled into large spiral screw conveyors, which in some cases have solid and in other cases perforated-screen bottoms. These conveyors discharge directly into the elevator cups, which in turn deposit the seed in another spiral screw conveyor. This brings the seed to the cleaning apparatus, known as a "boll reel." This is a perforated cylinder, revolving within a closed box. The perforations of the cylinder are larger than the seeds, allowing them to fall through into the closed box below, while retaining larger substances, consisting of bolls, carpels, pieces of cotton stalks, and sweepings, and the general trash from the ginneries. This trash is usually picked over by hand and such portion as may be of value is placed with the seed to pass through the linters. The balance of the trash is deposited in various ways about the building or outside. From the boll reel the seed is conveyed to a sand reel, which consists of a revolving steel cylinder, having perforations smaller than the cotton seed. Up to this point in the handling of seed at the mills, except in those cases where the conveyor has a perforated lining and supplementary screw conveyor for the trash, there are no devices that would have a tendency to eliminate the weevils. However, the sand reel permits boll weevils and other trash—in fact, everything smaller than the seeds—to pass to the chamber below, from which it is usually removed by hand and scattered outside of the buildings. It is very evident, therefore, that this is one point where the weevils are given an opportunity to spread from the oil mills. Nevertheless, excellent opportunity for the destruction of the weevils that have come from the gins is given at this point. This could be accomplished easily by collecting the refuse from the sand reel by means of a spiral conveyer, and passing it between such compression rollers as have been described previously. It is evident that all boll weevils remaining in the seed after it has passed through the sand reel must be carried with the clean seed through air-tight pipes into the seed bopper, which drops them upon the saws of the linter. Should any of the weevils escape the action of the sand reel they would certainly be killed by the close action of the saws of the linter.

Another very important point to be considered is in connection with the carriage of the seed to the oil mill proper. As has been stated, the conveyor runs the full length of the storage house on the outside of the building. In cases where a perforated bottom is provided, the refuse smaller than cotton seed passing through the bottom, which may include many weevils, is simply allowed to fall upon the ground. In other cases, however, this residue is collected by a spiral screw conveyor, to which compression rollers for the destruction of the weevil could be easily attached. If the screw conveyor were provided with an unperforated lining at the bottom, it would carry all weevils

which might not crawl out in transit to the elevator cups and thence to the sand boll reels. Most of the machinery used in the movement of the seed runs at a slow speed, and therefore a considerable percentage of the weevils may escape to the open air.

From the foregoing paragraphs it will be seen that to control the boll weevil at the oil mills would be a very difficult matter. The escape of the pest to the open air and to the hulls is allowed by the present necessary system of hand manipulation and the open conveyors with slowly revolving screws. The only recommendation to be made is that all conveyors should be provided with perforated bottoms, and that the trash passing through should be collected by means of a small spiral conveyor and passed between rollers. It is nevertheless true that this process would destroy only a small percentage of the weevils at the mills. The impossibility of applying any very effective method at the mills emphasizes strongly the necessity of vigorous attempts at the gins.

SUMMARY OF RECOMMENDATIONS.

It should be understood that complete success in keeping the boll weevil out of cotton seed depends upon a combination of the following recommendations for the seed-cotton storage house, in addition to a combination of the recommendations for the ginhouse proper. No one alone could be depended upon. On account of the great seriousness of the boll-weevil problem, the importance of these recommendations deserves the careful attention of every ginner, and farmers should realize that it is decidedly to their advantage to have their cotton ginned where the greatest care is taken with the seed.

I. Where possible, a separate seed-cotton storage house should be provided. In any case, the seed should be stored in a building distinct from the seed-cotton storage house.

II. In the seed-cotton storage house should be installed special cleaners or droppers, which, in addition to removing many weevils, would facilitate ginning and improve the sample.

III. In the ginhouse proper the principal recommendations are that cleaner feeders and cotton cleaners be used more extensively, that the trash therefrom be treated in such a way as to cause the destruction of the weevils, and that a device be perfected for removing and destroying the weevils in the seed and motes.

IV. Wherever the system of handling and ginning cotton is not found to be effective in removing the weevils, and this is the case in practically all the smaller and many of the larger ginneries in Texas and Louisiana, the seed, at least for planting purposes, should always be sacked and fumigated by the ginner in the manner described on

page 9. In regions where the cotton fields are isolated by this means the introduction of the weevils could be delayed considerably.

V. In addition to the care necessary with the seed for planting purposes, the farmer should also take great pains to prevent the introduction of the weevil in seed or hulls for feeding purposes, as well as in refuse from the ginneries, which is sometimes used as a fertilizer. There is no appreciable danger in cake or meal.

VI. At present it does not seem possible to control the boll weevil effectively at the oil mills. The importance the mills at present have in disseminating the weevil, however, could be very materially reduced by the proper care at gins.